The DSN Radio Observatory and Asia[illegible]acific VLBI Network

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Abstract

The current status of VLBI radio astronomy at the DSN is described. Recent upgrades of the radio astronomy and VLBI recording instrumentation will provide new capabilities (MKIV and S/2 (provided by the CSIRO, only at Tidbinbilla) for recording, two polarization receivers (at L- and K-bands, etc.) and will enhance VLBI radio astronomy at the DSN. Time allocation, compatibility issues, and operational interfaces between the DSN radio telescopes and the Asian Pacific VLBI network (APT) are discussed.

1. Introduction

Radio astronomy in the DSN has the goal of realizing and exploiting the potential of the DSN radio telescopes in those areas which compliment other radio astronomical observatories. Although the prime goal of NASA's Deep Space Network is to support space flight missions, nevertheless, in recognition of the value of large DSN radio telescopes for radio astronomy, NASA is allocating about 3% of the DSN antennas time for ground based radio astronomy research. Additionally, there are intergovernmental agreements between the US and Spain, and the US and Australia which provide to radio astronomers in Spain and Australia so called "Host-Country" time at the DSN telescopes. This additional time accounts for about 1% of the DSN radio telescopes time. VLBI radio astronomers have been for a long time the major users of the DSN's guest observing time. Due to the exceptional sensitivity of the DSN radio telescopes and their strategic location, this time has been in large demand among VLBI radio astronomers. Recent upgrades of radio astronomy and VLBI recording instrumentation will provide new capabilities and will enhance VLBI radio astronomy at the DSN. In the following paper, we will describe these new capabilities and discuss time allocation, compatibility issues, and operational interfaces between the DSN radio telescopes and the Asian Pacific VLBI network (APT).

2. Current Status of the DSN Radio Astronomy Facility and its Upgrades

The DSN radio astronomy facility (DSN Radio Observatory) is undergoing a major upgrade in its hardware and operations for radio astronomy. Since support of flight missions is the prime goal of the DSN, these upgrades have been made largely for Space VLBI coobserving in support of the VSOP and Radioastron missions.

The DSN is upgrading its L- and K-band radio astronomy receivers to make them more reliable, sensitive, and to allow two polarization observations at these wavebands. The VLBI recording capabilities are being upgraded to MKIV. The monitor and control computers are being replaced to automate radio astronomy observations, remotely monitor them, and make the DSN radio astronomy facilities more user friendly. Additionally, the CSIRO (Commonwealth Scientific and Industrial Research Organization) in agreement with NASA placed a S/2 recorder at the Canberra Deep Space Communication Complex (CDSCC). The current plan is to finish the radio astronomy equipment and VLBI recording capabilities upgrade required to support SVLBI at Goldstone before the end of 1996, at Canberra in April 1997 and in Madrid in June 1997.

The DSN Radio Observatory facilities configuration and parameters as they will be implemented in 1997 are given in Table 1

Table 1. The DSN Radio Observatory Facility (" Y Configuration)

DSN Complex Location	Antenna	Dia meter (m)	Receiving frequency band (GHz)	Type SEFD (Jy)	Wavelength/ polarization channel configuration	+ Frequency Steered	VLBI Recording capability	Spectrum Analyzer	Type of RA observation to be performed
Goldstone, CA, USA, (GDSCC)	DSS43	34	31.8-32.3 40-50	300 800	LCP&RCP simult. S&X simult.	Hydrogen Maser/GPS	Mk4V	BW=40 MHz, Number of ch = 2097152*	Spectroscopy VLBI
	DSS14	70	1.6-1.73 2.2-2.3 7.8-8.7 18-26	20 15 20 55	LCP&RCP simult. S&X simult.				Spectroscopy Continuum Pol. mixed on VLBI
	DSS15	34	2.2-2.3 8.2-8.6	160 130	LCP&RCP simult. S&X simult.				VLBI
	DSS42	34	2.2-2.3 8.4-8.6	160 130	LCP&RCP simult. S&X simult.				VLBI
Canberra, Australia (CDSCC)	DSS43	70	1.6-1.73 2.2-2.3 8.4-8.6 12-18 18-26	20 15 20 50 55	LCP&RCP simult. S&X simult.*	Hydrogen Maser/GPS	Mk4V & S/2 (CSIRO)	BW=20 MHz, Number of ch = 16384	Spectroscopy Continuum Pol. mixed on VLBI
	DSS45	34	2.2-2.3 8.2-8.6	160 130	LCP&RCP simult. S&X simult.				VLBI
Madrid, Spain (MDSCC)	DSS63	70	1.6-1.73 2.2-2.3 8.4-8.6 18-26	20 15 20 55	LCP&RCP simult. S&X simult.	Hydrogen Maser/GPS	Mk4V	BW=10 MHz, Number of ch = 2048	Spectroscopy Continuum Pol. mixed on VLBI
	DSS65	34	2.2-2.3 8.2-8.6	160 130	LCP&RCP simult. S&X simult.				VLBI

* Used Linear Polarization in 12-16 GHz channel

3. DSN and APT

3 DSN Radio Telescopes as a Part of the APT

The DSN antennas are among the most valuable APT radio telescopes at centimeter wavelengths due to their location and sensitivity. Participation of the DSN radio telescopes in CDSCC and Goldstone (GDSCC) with the APT significantly improves the performance of the network in terms of sensitivity (see Table 2)

Table 2 . DSN and APT

Wavelength (cm)	Telescopes	Min SEFD (Jy)	$SEFD_{tot}$	Max record bit rate (Mbit/sec)*	Best Baseline Sensitivity (mJy)**	Image Sensitivity (mJy/beam) ***
18	NA,MO,PA,HO,KA, US,SHUR,HA	85	238	128	0.24	29
	APT-DSS43-DSS14	40	129	128	0.11	
13	NA,MO,PA,HO,KA, US,SHUR,HA	90	219	128	0.26	27
	APT-DSS43-DSS14	15	71	128	0.04	7
3.6	NA,MO,PA,HO,KA, US,SHUR,HA	90	213	128	0.26	26
	APT-DSS43-DSS14	20	85	128	0.06	8
1.35	PA,HO,KA,NO,SH,UR,	220	929	128	0.63	177
	APT-DSS43-DSS14	55	212	128	0.16	29.5

Limited by S/2 capability

* Integration time 2 min; correlation efficiency 0.5

** Observing time 8 hr

3.2. Compatibility Issues

As stated above, in the course of upgrading the DSN VLBI facilities, the MKIII DAT at the DSN complexes will be upgraded to MKIV. Since the APT evidently is progressing to mainly VLBI S-2 recording for astrophysical observations, potentially it creates a compatibility problem in using the DSN facilities for these observations along with the APT. Earlier this year (1996), the CSIRO in agreement with NASA purchased and installed an S-2 recorder at CDSCC. Though that technically resolves the compatibility issue for using CDSCC telescopes in S-2 VLBI sessions, it does not solve the operations problem. This S-2 recording terminal does not have the DSN's operational status. This means that the DSN does not plan to maintain and operate this terminal. VLBI operations with recording on an S-2 system at the CDSCC must be done with the direct support of CSIRO. The DSN will fully support the VLBI sessions with MKIV recording. These include VLBI geodetic experiments, radio astronomy observations and Space VLBI which plan to be processed with the MKIV compatible correlators.

3.3. DSN - APT Interfaces

The DSN Science Office is managing the DSN's radio astronomy facility upgrades and radio astronomy operations including the upcoming Space VLBI coobserving. The goal of this office is to ensure that the DSN radio astronomy facilities will become state-of-the-art radio astronomy facilities which will be able to support modern radio astronomy observations and to provide the guest radio astronomers with the necessary expertise to successfully execute such observations with the DSN radio telescopes.

Historically, most of the guest radio astronomy observations at CDSCC (including VLBI) have used the time allocated for such research under "Host-Country Agreement" and "CSIRO-NASA Cross Support Agreement" (agreement between the CSIRO and NASA to have access to each others telescopes for radio astronomy purposes). The time allocation history of the last few years for radio astronomy research at the DSS43 is given in Figure 1.

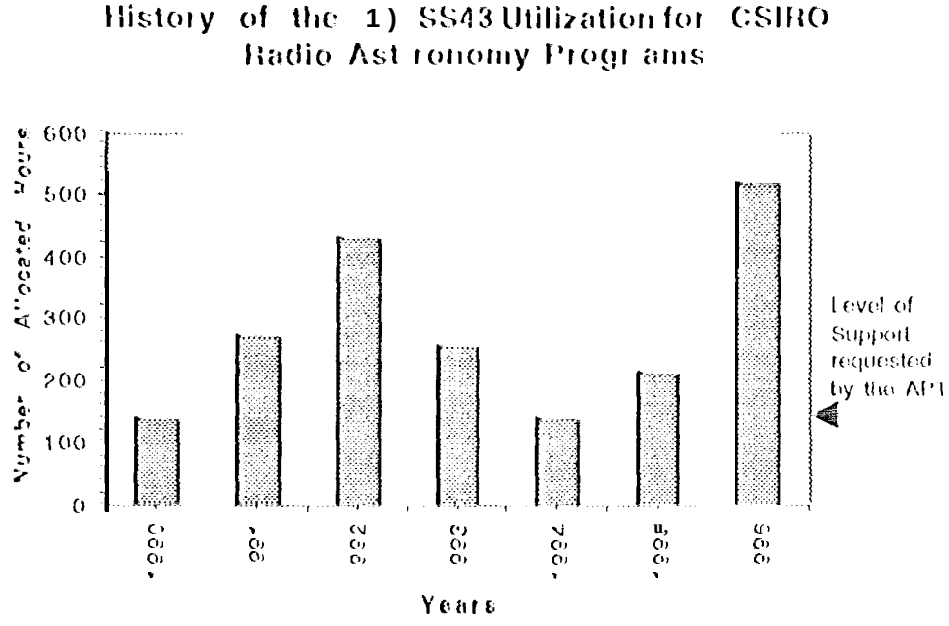

Figure 1.

According to these agreements, NASA(JPL) allocates this time at the CDSCC antennas on non-interference basis and the experiment selection and scheduling process is managed by the CSIRO. The support of the APT operations will require the allocation of at least 144 hr (3 observing sessions of 48 hr each) per year during particular times of the year. These sessions must be coordinated with the other radio telescopes in the network. These 144 hr per year will take a significant part (if not 100%) of the amount of time available for radio astronomy under the above noted agreements at the 70m antenna in CDSCC (DSS43), which is the most valuable for radio astronomy. To avoid conflict with other 70m telescope radio astronomy users, while some APT experiments may be allocated the DSS43 support within the existing "Host-Country" and "CSIRO-NASA Cross-Support" programs, the APT also may apply for it's own allocation of an additional time at this 70m telescope and at the 70m telescope in Goldstone through submitting a proposal to the DSN Science Office (JPL). The need to negotiate the particular time at the DSN antennas when the other APT network telescopes are available will require more formal arrangements between the JPL operations/scheduling and the APT. Finally, for those experiments using the S-2 recorders, or other non-DSN equipment at CDSCC, the CSIRO shall provide all of the necessary operational support (VLBI schedule processing, recorder operations).

4. Conclusion

The newly-upgraded VLBI radio astronomy DSN facilities in CDSCC and GDSCC will provide valuable input to the APT. Since the DSN facilities continuously evolve to meet the demands of NASA flight projects or DSN operations and engineering, it is evident that DSN radio astronomy developments must be closely coordinated with the requirements of the DSN science users. It is important to have a close technical and science operations contact between the DSN Radio Observatory and the APT. The feedback from the VLBI radio astronomy community on the performance of the DSN radio telescopes and on the features desired to support future observations will help to develop the DSN's science and technical policies.

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